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In This Issue

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This is the first issue of the Inputs Outlook and Situation. The next issue is scheduled for October 1983, and subsequent reports will be published quarterly. Future issues will assess supply, demand, and price prospects for pesticides, farm energy, farm machinery, and fertilizer. Subscriptions to the Inputs report will be available from the U.S. Government Printing Office at a price still to be determined. For price and ordering information write: Inputs, USDA/EMS, 440 GHI, Washington, D.C. 20250. Or call (202) 447 4230.

Summary

High participation in acreage reduction programs, including the payment-in-kind (PIK) program, will limit farm use of pesticides and energy this season, and dampen early-year sales of new farm equipment. Prospects for only a modest improvement in farm income and high interest rates are also holding down demand.

U.S. farmers are cutting pesticide use by an estimated 15 percent to 18 percent due largely to a nearly 30-percent reduction in prospective corn and cotton acreage. Farm energy consumption will also be down substantially, as gasoline use drops 11 to 14 percent and diesel fuel consumption slips 14 to 16 percent. Lower demand for farm energy this year also reflects continued conservation efforts by farmers to trim costs. Farm machinery will probably be least affected by PIK. After falling drastically for several years, sales may slip only 2 to 3 percent this year. The PIK program may well spark a turnaround in the second half of 1983, as crop prices

average above year-earlier levels and farmers can no longer put off replacing old equipment.

Farm expenditures for pesticides, fuel, and machinery purchases, repairs, and maintenance this year may total around $30 billion, compared with $33 billion in 1982, when total farm expenditures were $144 billion. High PIK participation and large pesticide supplies are keeping prices slightly lower than a year ago, while farm fuel prices will be down 2 to 3 percent. Following stiff increases over the past decade, farm machinery prices in March 1983 were up only 2 to 3 percent from last fall. Further price hikes this year will be well below 1982's 8-9 percent.

Pesticide supplies will be plentiful in 1983, as beginning stocks are up about 3 percent, despite an expected 9-percent drop in production. The increase stems from a 35-percent gain in inventories over the previous year. Despite a planned 5-percent cut in herbicide production, beginning supplies rose about 8 percent due to a large inventory carryover. Insecticide supplies are expected to drop by about 6 percent due to a planned 14-percent production decline.

Producers of basic pesticides expect to export 21 percent of their 1983 herbicide production and 29 percent of insecticide output, down about 10 percent and 5 percent from last year.

Pesticide research has produced a number of new herbicide products designed especially for postemergent and limited tillage use, as well as several new synthetic pyrethroid insecticides that can be applied at reduced rates. Scientists now are focusing on methods to apply pesticides more precisely.

Because of reduced plantings, a cutback in irrigated acreage, and an overall decline in energy prices, this year's farm energy expenditures will be down about $1.3 billion, almost 14 percent below 1982's $10.2 billion. Gasoline expenditures are likely to drop more than $600 million, diesel fuel about $750 million, and LP gas as much as $110 million. The anticipated cost reductions will well exceed an expected $30-million increase in outlays for electricity.

Farmers can look for gasoline and diesel fuel prices to decline from 1982 levels, while electricity, natural gas, and LP gas prices likely will rise somewhat faster than the inflation rate. Average diesel fuel prices may be down 9 to 12 percent to about a dollar a gallon, while gasoline prices could retreat 3 to 5 percent to $1.18. However, electricity prices are likely to average 8 percent higher, and continuing deregulation could push natural gas prices 6 to 8 percent higher to about $4.17 per thousand cubic feet.

The increase in natural gas prices will have little effect on direct farm energy costs, since relatively little natural gas is used on farms as fuel. However, steeper natural gas prices could pressure the profit margins of grain elevators that use the gas to dry grain and cause some losses to nitrogen fertilizer producers who use it as a raw material. LP gas prices could climb 6 to 8 percent over last year. An expected upturn in the economy, coupled with increasing petrochemical demand for LP gas and the continuing impact of natural gas deregulation, will probably keep wholesale LP prices relatively high.

Farm operations are expected to use about 2.4 to 2.5 billion gallons of gasoline in 1983, compared with 3 billion in 1981 and 2.8 billion in 1982. Farm diesel fuel consumption is forecast at 2.7 to 2.8 billion gallons, down from 3.2 billion last year. LP gas use may drop 15 to 25 percent and electricity use 5 percent from 1982.

In 1984 farm energy prices are projected to rise slightly, after accounting for inflation. However, diesel fuel prices are likely to advance more than other fuels.

The outlook for farm machinery is improved over the depressed market of the last several years. However, any substantial improvement in machinery purchases is not likely to occur until 1984. Sales continued lower in first-quarter 1983, but dealers in many areas reported that sales picked up considerably in April and May. Several companies were offering farmers credit advances on their PIK payments.

While new machinery purchases may drop only slightly, repair and maintenance costs may be down 12 to 15. This decline is being offset to some extent by greater repair bills as farmers have been delaying machinery replacement for several years.

Machinery prices in the last 10 years have gone up more than the overall index of farm inputs. During 1972-82, machinery prices tripled, while prices of all production items rose 135 percent and farm commodity prices doubled.

Because of the depressed farm machinery market of the past several years, at least 2 major manufacturers have experienced severe financial difficulties. All farm machinery producers have had to substantially cut output, shut down some facilities, and lay off large numbers of workers. Plans for early 1983 called for further cutbacks, with improvement anticipated later in the year.

Inputs Outlook and Situation

PESTICIDES

Pesticide Demand

Farm pesticide use is expected to decline about 15 to 18 percent in 1983 with larger decreases for some crops. The drop is largely attributed to reduced acres resulting from the payment-in-kind (PIK) program. Other demand dampening factors include farm income, continued relatively high interest rates, and the growing use of pesticide-conserving technologies.

Because pesticides comprise a small share of total production costs for many major crops and because pesticides must generally be used at specified rates, no significant reduction in pesticide use is expected as a result of depressed economic conditions. For four of seven major field crops, pesticides accounted for less than 10 percent of total production costs in 1981. However, pesticide costs for peanuts amounted to about $79 per acre, or 13 percent of total production costs, but for wheat they were just over $2 an acre or 2 percent of all costs (table 1).

Although demand is down because of reduced acreage due to PIK, the program has ironically created some opportunities for both pesticide manufacturers and marketers. Herbicides, especially, will be needed on some soil-conserving crops to control persistent weed problems.

Table 1.—Costs of pesticides for selected U.S. crops, 1979 and 1981

Crop	Pesticide expenditures per acre		Share of total production costs[1]	
	1979	1981	1979	1981
	Dollars		*Percent*	
Corn	13.27	15.49	7.4	6.3
Sorghum	6.22	7.28	5.2	4.5
Wheat	2.08	2.29	2.3	1.8
Rice	21.54	24.98	6.8	5.9
Soybeans	12.78	14.73	11.1	10.0
Peanuts	65.29	78.91	16.1	13.2
Cotton	34.92	42.59	11.0	10.1

[1]Total production costs exclusive of land.

Source: (20).

Herbicides

Herbicide use grew dramatically in the 1960's and increased throughout the 1970's, with the proportion of treated corn acreage rising from 69 to 93 percent and soybean acreage from 71 to 92 percent between 1972 and 1980 (tables 2 and 3). In 1982, the proportion of corn acreage treated for weed control increased slightly to 95 percent and soybean acreage treated increased to 93 percent.

However, because of the drop in crop acreage, herbicide use this season is down. Total herbicide quantities used in 1983 are likely to be 13 to 16 percent below use in 1982. For the major crops, the proportion of acreages treated with herbicides in 1982 was: 95 percent for corn, 93 percent for soybeans, 42 percent for wheat, and 97 percent for cotton. Planted acres of corn and cotton are likely to be down nearly 30 percent in 1983, largely because of PIK (table 4). For soybeans, the second largest herbicide user, acreage is expected to decrease by about 8 percent.

Expanding use of reduced cultivation and no-till practices generally increases the need for herbicides. Also, increasing applications of selective postemergent herbicides for problem weed infestations are being used to supplement preemergent herbicides, and many growers are using improved application equipment such as recirculating sprayers and wick applicators. Last year, weather conditions during the planting season induced some farmers to switch from preplant incorporated herbicides to preemergent herbicides applied after tillage. Demands for each of the respective types of herbicides again depended heavily upon weather conditions.

Table 2.—Corn acreage planted and treated for weed and insect control, 1972 and 1980

Region[1]	Acres treated					
	Planted acres		Weed control		Insect control	
	1972	1980	1972	1980	1972	1980
	Million		*Percent*			
Corn Belt	33	41	81	98	31	40
Northern Plains	11	13	48	81	29	56
Lake States	11	14	70	95	18	40
Southeast	3	4	50	78	2	14
Total	58	72	69	93	25	43

[1]These regions accounted for 86 percent of the corn acres planted in 1982.

Source: (8).

Table 3.—Soybean acreage planted and treated for weed and insect control, 1972 and 1980

Region[1]	Acres treated					
	Planted acres		Weed control		Insect control	
	1972	1980	1972	1980	1972	1980
	Million		*Percent*			
North Central	29	40	76	96	NA	2
Mississippi Valley	11	17	64	91	3	15
Southeast	4	9	46	76	10	47
U.S.	44	66	71	92	1	11

[1]These regions accounted for 88 percent of the soybean acres planted in 1982.

NA = Not available.

Source: (9).

Table 4.—Acreages planted for selected crops in 1982 and planting intentions for 1983

Crop	1982	Indicated 1983	Percent change 1982 to 1983
		Million acres	
Corn	82	59	−28
Sorghum	16	12	−25
Wheat	87	77	−11
Soybeans	72	66	−8
Cotton	11	8	−27

Source: (20).

Insecticides and Fungicides

Insecticide use is expected to decline by 15 to 18 percent in 1983 compared with a 3 to 4-percent drop in 1982. The need for insect control fluctuates not only with planted acreage but also with weather conditions. This year, sharply reduced corn and cotton acreage is the major reason for the drop in insecticide demand.

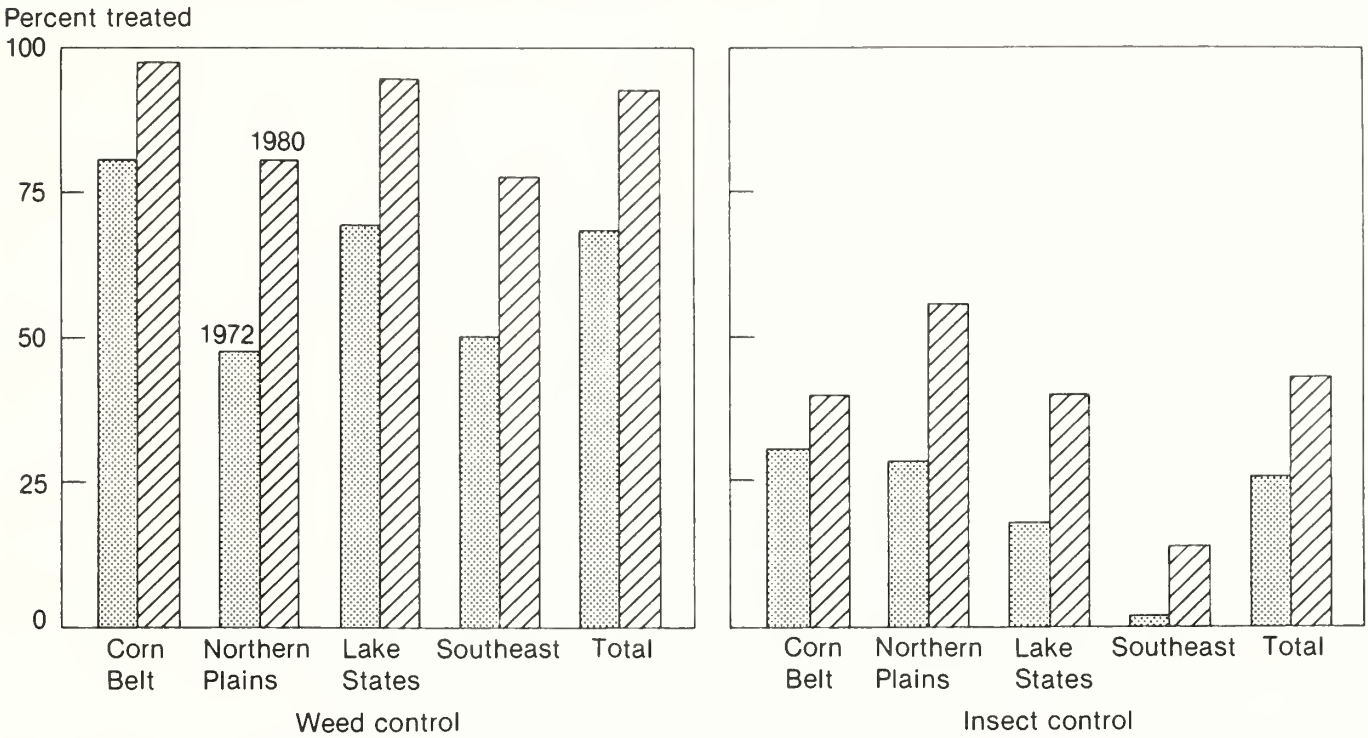
Severe winter conditions in many of the major crop producing areas reduced insect hatches and the need for insecticides in 1982. Despite the milder 1982/83 winter, the amount of cotton insecticides used per acre is generally declining. Fewer insecticide treatments and less active ingredients may be needed for cotton because of integrated pest management with insect counts to monitor infestation levels and the use of synthetic pyrethroid insecticides which are used at much lower rates and are less harmful to beneficial insects.

Pesticide Use

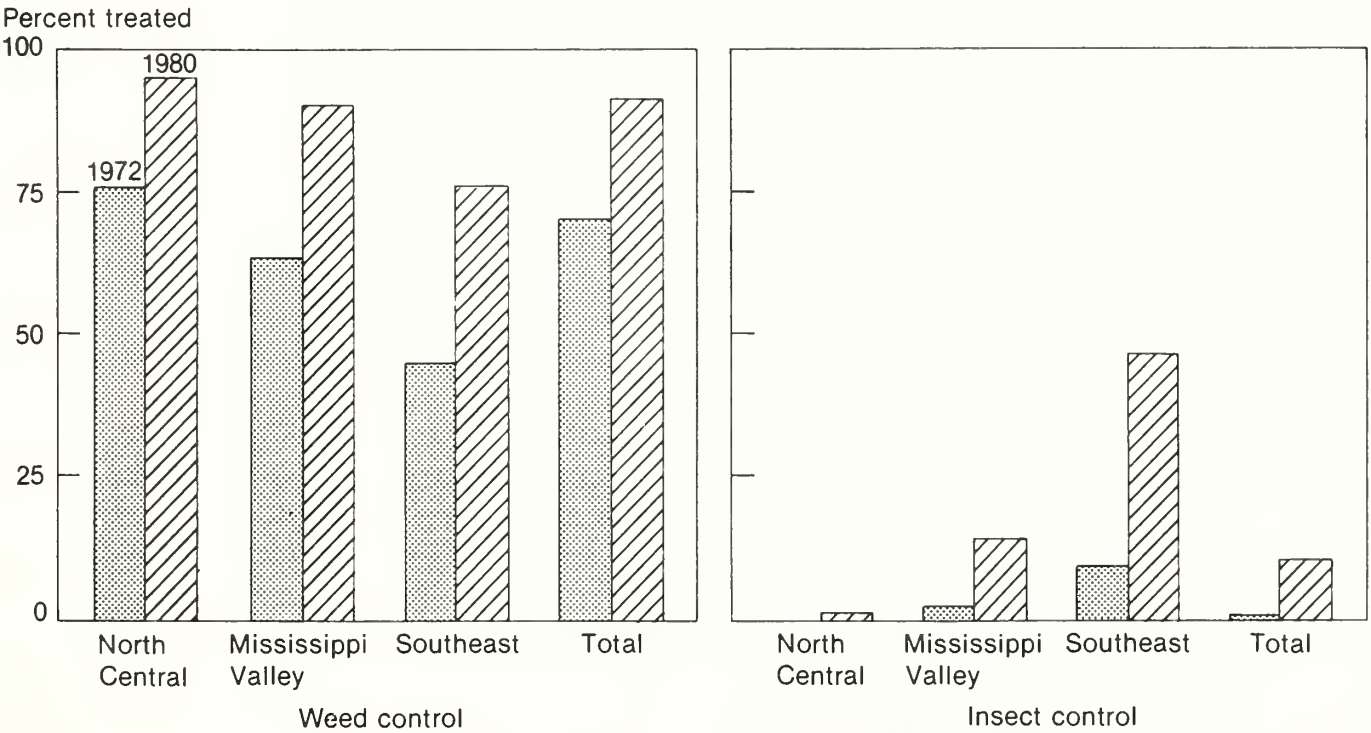
Quantities of Pesticides Used

For major crops the quantity of herbicides used has grown most rapidly. From 1964 to 1971 the use of herbicides tripled, and from 1971 to 1976 their use increased from 216 million pounds active ingredients to 375 million

Corn Acreage Treated for Weed and Insect Control



Soybean Acreage Treated for Weed and Insect Control



pounds (table 5). Preliminary estimates for 1982 indicate herbicide use continued to increase to 420 million pounds, an increase of 12 percent from 1976. The crop using the greatest amount of herbicides in 1976 and 1982 was corn (207 and 121 million pounds). Wheat, cotton, sorghum also used significant amounts of herbicides.

Insecticide use showed a small upward trend in use over the 1964-76 time period, increasing from 117 to 130 million pounds in 1976. From 1976 to 1982 insecticide use dropped to about 54 million pounds (a.i.). This occurred principally as a result of reductions in the proportion of cotton and peanut acreage treated and changes in specific insecticides used on cotton. In 1976 nearly 50 percent of the major field crop insecticide use was in cotton production, with corn uses accounting for another 25 percent. Since 1976, materials registered for use on cotton, specifically the synthetic pyrethroids, are applied at very low application rates of 0.1 pound (a.i.) compared to the traditional organic insecticides where application rates per acre were in the 1- 3 pound range.

Acres Treated

For herbicides, acres treated jumped from 88 million acres in 1964 to 189 million acres in 1976 and increased further to nearly 220 million acres in 1982 (table 6). The upward trend continued, but at a slower rate of increase.

Acres treated with insecticides had a small upward trend over the 18-year time span increasing from about 60 million acres in 1964 to 66 million acres in 1976, but then decreased to 54 million acres in 1982. It is difficult to tell with only one year of data if the small upward trend in acres treated with insecticides has reversed because of the yearly variability in insect populations. Also, increasingly, farmers are scouting fields and applying insecticides only when a problem exists, but a comprehensive study has not been conducted to determine the impact on pesticide practices.

Pesticide Supplies

For the 1983 season, pesticide supplies are plentiful due mostly to large inventory carryovers from 1982. Inventory carryover as a percentage of pesticide production amounted to 49 percent for herbicides, 42 percent for insecticides, and 46 percent for fungicides. This was the second year with large beginning inventories. Stocks carried over into the 1982 season averaged about one-third of the previous year's production. Normally a producer's carryover stock of 15 to 20 percent is considered desirable. Because of weak demand and large inventories, manufacturers cut production substantially during the year to bring supplies in line with demand and avoid a large carryover into the 1984 season.

Herbicide supplies for the 1983 season were expected to be about 8 percent larger than last season (table 7). For the 1983 season, insecticide manufacturers expected a 6-percent decline in supplies with about a 14-percent drop in production, which was not sufficient to offset an inventory carryover totaling 42 percent of 1982 output.

Overall, pesticide producers operated at 65 percent of capacity in 1982—down from the 80 to 90-percent levels of the mid-to-late 1970's (table 8). Facilities were expected to operate at 60 percent of capacity or less during 1983. Pesticide manufacturers planned to increase capacity by less than 1 percent in 1983, compared with an estimated 7-percent addition in 1982. Insecticide facilities were expected to be operating at just over 50 percent of capacity, down from an already low level of 60 percent in 1982. With this excess capacity, little new construction was planned.

Capacity utilization rates for herbicides are generally higher than for insecticides, but are also low this year compared to historic standards. Last year's 71 percent utilization rate was expected to decline to 67 percent or less in 1983. Plans for capacity expansion were limited to less than 1 percent.

Table 5.—Pesticide use on major field crops[1]

Pesticide	1964	1966	1971	1976	1982[2]
			(Million pounds (a.i.)		
Herbicides	70.5	102.1	216.1	373.9	420.4
Insecticides	116.7	108.3	128.6	130.3	53.8
Fungicides	5.7	6.0	6.4	8.1	5.2

[1]Includes corn, soybeans, cotton, wheat, sorghum, rice, other small grains, tobacco, peanuts, alfalfa, other hay and forage, and pasture and rangeland. [2]Preliminary estimates only. Includes 32 major producing States, excluding California.

Source: USDA, ERS Pesticide Use Surveys, 1964, 1966, 1971, 1976, 1982.

Table 6.—Acres of major field crops treated with pesticides one or more times[1]

Pesticide	1964	1966	1971	1976	1982[2]
			(Million acres)		
Herbicides	88.2	107.8	151.0	189.3	219.8
Insecticides	59.7	55.9	49.2	66.3	54.2
Fungicides	4.5	2.7	3.8	5.7	3.7

[1]Includes corn, soybeans, cotton, wheat, sorghum, rice, other small grains, tobacco, peanuts, alfalfa, other hay and forage, and pasture and rangeland. [2]Preliminary estimates only. Includes 32 major producing States, excluding California.

Source: USDA, ERS Pesticide Use Surveys, 1964, 1966, 1971, 1976, 1982.

Table 7.—Pesticide production, inventories, and exports

Item	Herbicides	Insecticides	All pesticides
		Percent	
Projected 1983 production (percentage of 1982)	95	86	91
Inventory carryover: For 1983 (percentage of 1982 production)[1]	49	42	46
Change from 1982	47	19	35
Projected 1983 exports (percentage of 1982 exports)	90	95	93
Projected 1983 net supply (percentage of 1982)	108	94	103

[1]Inventories at the start of the 1982 and 1983 season are based on production in 1982.

Source: Survey of basic pesticide producers, October-December 1982.

Prices

Early in the year, pesticide prices averaged slightly less than last season, primarily because of large supplies and weak demand, which spurred producers and dealers to try various incentive programs to encourage early movement. However, many farmers did not buy pesticides until they needed them. It was expected that prices would decline later in the season due to acreage reductions and delayed plantings caused by unusually wet field conditions in certain areas this spring. Herbicide prices did continue to decrease, while insecticide prices increased by 8 percent between May 1982 and May 1983. The increase was largely due to rises in the prices of toxaphene and carbofuran.

As of mid-May 1983, herbicide prices were down about 4 percent from May 1982 (table 9). Insecticide prices were up almost 8 percent and fungicide prices were also up slightly. Synthetic pyrethroid insecticides also continued their price decline with the introduction of several new products and the drop in cotton acreage. Reduced cotton acreage also slowed price advances and caused price cuts for certain other insecticides. The price of toxaphene, however, was up 16 percent compared with a 5-percent rise last year. This increase is probably due to increased purchases by farmers in anticipation of the announced restriction for use on cotton.

During 1982, pesticide prices advanced an average of 2 to 6 percent, compared with an average of 7 to 15 percent in 1981 (table 9). Insecticide prices rose 6 percent, herbicides, about 2 percent, and fungicides, about 4 per-

Table 8.—Pesticide production, capacity utilization, and capacity expansion plans

Pesticide	Production as a percentage of capacity		Capacity expansion percentage change	
	1982	Projected 1983	1981/82	Projected 1982/83
		Percent		
Herbicides	71	67	4	.5
Insecticides	60	51	7	.25
All pesticides	65	60	7	.4

Source: Survey of basic pesticide producers, October-December 1982.

Table 9.—Average prices paid by farmers for selected pesticides

Product[1]	Price per pound (active ingredient)[2]				Price change		
	1980	1981	1982	1983	1980-1981	1981-1982	1982-1983
			Dollars			*Percent*	
Insecticides							
Carbaryl	2.86	3.25	3.55	3.65	14	9	3
Malathion	3.17	3.43	3.72	3.74	8	8	1
Methyl parathion	2.28	2.45	2.61	2.66	7	7	2
Parathion	3.02	3.30	3.47	3.40	9	5	2
Toxaphene	1.26	1.32	1.39	1.61	5	5	16
Carbofuran	7.84	9.00	9.56	10.24	15	6	7
Pyrethroids	NA	88.50	85.00	73.00	NA	−4	−14
Average	NA	NA	NA	NA	8	6	8
Herbicides:							
Atrazine	2.32	2.83	2.68	2.50	22	−5	−7
Alachlor	4.04	4.41	4.81	5.00	9	9	4
Trifluralin	7.00	8.20	8.55	7.70	17	4	−10
2,4-D	2.93	2.95	2.80	2.64	1	−5	−6
Butylate	2.80	3.22	3.43	3.37	15	7	−2
Average	NA	NA	NA	NA	15	2	−4
Fungicides:							
Zineb	2.27	2.44	2.52	2.72	7	3	8
Captan	3.36	3.60	3.76	3.68	7	4	−2
Average	NA	NA	NA	NA	7	4	3

[1]Carbaryl, 80 percent wettable powder; malathion, 5 pounds per gallon; methyl parathion, 4 pounds per gallon; toxaphene, 6 pounds per gallon; carbofuran, 10 percent granule; synthetic pyrethroids, 2.0 to 3.2 pounds per gallon; atrazine, 80 percent wettable powder; alachlor, 4 pounds per gallon; trifluralin, 4 pounds per gallon; 2,4-D, 4 pounds per gallon; butylate, 6.7 pounds per gallon; zineb, 75 percent wettable powder; and captan, 50 percent wettable powder. [2]May 15th each year.

NA = Not available.

Source: (17).

cent. For herbicides, some prices fell. After rising 22 percent in 1981, the price of atrazine dropped 5 percent in 1982. The price of 2,4-D also declined 5 percent. Trifluralin prices climbed only 4 percent, following a 17-percent rise in 1981. Trifluralin is facing increasing competition from newer products in the soybean and cotton markets. The price rise for butylate dropped from 15 percent in 1981 to 7 percent in 1982. Alachlor prices advanced steadily at 9 percent in 1981 and 1982.

Among insecticides, carbaryl, carbofuran, and parathion all showed smaller price increases in 1982 than in 1981. Methyl parathion, which is used extensively on cotton, is facing growing competition from synthetic pyrethroids.

Distribution

Current economic conditions in the farm sector and industry led to stiffer price competition at the retail level. Many dealers have recently had to rely more on cash discounts rather than attractive credit terms as sales inducements. To move their inventories, many manufacturers have offered rebates to distributors that pay cash on delivery. Because of the rebates, many wholesale distributors take early delivery and attempt to move the pesticides quickly. This in turn leads to further downward price pressure.

To maintain profit margins, both distributors and dealers attempt to differentiate their products. Products are tailored to match soil and weather conditions in the regions they are marketed. Many distributors prepare preformulated tank mixes to farmers' specifications and retain agronomists who determine what materials to use and when and how to apply them. They also recommend formulations most suitable for soil and weather conditions in their market area. Most dealers carry a broad array of pesticides, and therefore, have considerable flexibility in recommending which pesticides farmers should apply.

Many suppliers now use computers to assist in recommending particular pesticides, application rates, and timing. Variables include pest infestation, pest tolerance levels, soil and climatic conditions, and cultural practices used. In addition to advising on efficient pesticide use, more dealers are offering custom services to apply the products they sell.

Domestic Industry Trends

A major cost in basic pesticide production is research and development. The long period required to recover the high costs of research and development prevents companies without substantial capital from attempting to develop new products and discourages new firms from entering the industry. A recent survey of basic pesticide manufacturers indicated that they spent an average of nearly $20 million over an 8 to 9-year period to develop one product. Largely due to high research and development costs, there may be fewer companies producing new pesticides in the 1990's than exist today.

To compete in certain markets, some manufacturers save on new product development by emulating successful products without duplicating them. This practice may encourage price competition for specific control problems but wastes research resources that might otherwise be used to develop completely new products.

In recent years, the use of tank mixes has been increasing. Progressive dealers are generally anxious to provide this service. Manufacturers producing complementary tank mix products sometimes engage in joint marketing efforts.

The use of more cooperative research agreements is also likely. Research and development activities of the major agrichemical firms have often resulted in duplicate effort and patent overlap. To avoid this difficulty, some firms may pool their resources while testing and collecting data necessary for a product's development and registration—and possibly share patent rights.

Joint agreements between basic pesticide producers and firms that formulate and package materials are common. Large diversified firms are also acquiring technically innovative small firms. The acquiring firm is often better able to sustain the high risk and costs associated with product development.

International Industry Trends

Multinational firms are becoming increasingly important in the United States pesticide industry. These firms often infuse new capital and technology in the domestic market and increase the world market potential of domestic firms. To safeguard patents, some multinational U.S. pesticide firms are likely to centralize research, development, and production of proprietary products, while decentralizing their production of nonpatented pesticides. Countries that lack hard currency are likely to produce more pesticides for which patents have expired.

Foreign-owned companies that have been operating in the United States for several years include: Bayer, a German company, with its U.S. agrichemical operation, Mobay; Royal Dutch Shell; and the Swiss company, Ciba-Geigy. More recent entrants include ICI (Imperial Chemical Industries of Great Britain); BASF of Germany, which purchased the Wyandotte company; BFC Chemicals of Britain which acquired Hercules, and Rhone Poulenc of France that acquired the agricultural chemical operations of Mobil Oil Corporation. Degesch of Germany and Sumicomo Chemicals of Japan also have U.S. pesticide operations, and several other foreign firms are apparently seeking similar operations.

Although specific market shares cannot be identified, Ciba-Geigy has long been a leading U.S. herbicide producer with its triazine products. ICI pioneered the introduction of synthetic pyrethroid insecticides, and Mobay has long produced a variety of insecticides for a broad array of uses. Together, these companies account for an important and increasing share of the U.S. market.

Exports account for a large proportion of United States pesticide manufacturers' revenues. At the midpoint of the 1983 production year, exports are expected to comprise 21 percent of herbicide production and 29 percent of insecticide production. Export volume may be down 7 percent for all pesticides, 10 percent for herbicides, and 5 percent for insecticides (table 7). These reductions are in line with production cuts for domestic markets.

Distribution overseas is costly as pesticide companies frequently purchase local companies, acquire established distribution networks, or market through other companies. Due to the primitive infrastructure in many third world countries, marketing through established companies is often the most viable marketing strategy. In fact, foreign operating subsidiaries of many American

multinational firms frequently engage in trading third party products.

New Pesticides

Herbicides

Corn and soybeans offer the greatest opportunities for continued growth in world herbicide markets. In 1981, world revenues for soybean herbicides reportedly approached $950 million, while those for corn herbicides reached $900 million. Among the most promising products are improved postemergents, many of which are still under development and awaiting registration. Some of the recently introduced and planned herbicide products are shown in table 10.

Farmers using reduced tillage systems need combined pre- and postemergent herbicide products to kill existing weeds and weeds which may subsequently germinate. No-till strategies allow a wide variety of weeds to germinate that would otherwise be destroyed by more complete cultivation. Glyphosate, a nonselective herbicide, destroys root systems of already emerged weeds, but does not prevent the germination of weed seeds on or near the soil surface. Because paraquat and glyphosate (herbicides used to kill existing weeds at planting time) are nonselective, they can damage a growing crop and must be applied before the crop emerges. Application equipment is under development that can apply some broad spectrum herbicides without affecting the crop. For example, manufacturers have designed an applicator that uses herbicide-soaked rope brushes to cover the surface of tall weeds without coming in contact with the shorter crop plants. Manufacturers are also developing substances, which, when added to some nonselective herbicides, increase the tolerance of certain crops for these herbicides.

Pesticide manufacturers are seeking ways to manipulate molecular structures to produce postemergent herbicides that can be used in lower doses. Plant geneticists and biotechnologists are using gene splicing to develop crop strains that can tolerate herbicides.

Insecticides

Synthetic pyrethroid insecticides have drastically altered the mix of chemicals used by cotton growers in recent years and have reduced the quantity of active ingredients applied. Synthetic pyrethroids are not considered effective against soil insects because they break down quickly in the soil. This has prevented pyrethroids from penetrating the large market for treating corn soil insects such as the rootworm and cutworm. Pyrethroids have also proven ineffective against some foliar corn insects such as aphids and mites. However, a synthetic pyrethroid called PP563, which appears to be effective against corn mites, is currently being developed. The synthetic pyrethroid insecticides currently available, or being developed, are shown in table 11.

Some newer pyrethroids can be used in lower doses than the materials first introduced. New products such as cypermethrin and flucythrinate require only between .025 and 0.1 pound of active ingredient per acre compared with fenvalerate and permethrin, which require between 0.1 and 0.2 pounds. Labels have also been modified with instructions for timely applications to control particular pest problems.

Table 10.—New herbicides recently developed or planned for market entry

Product	Type	Projected Market	Registration date
HOE - 661	Postemergent	No-tillage	1985-1986
Whip	Postemergent	Soybeans	1984
Poast	Postemergent	Soybeans	1983-1984
CGA-82725	Pre& postemergent	Soybeans	1985-1986
Dowco-356	Postemergent	Corn	1984
Dowco-453	Pre & postemergent	Soybeans	1985-1986
Glean	Pre & postemergent	Wheat	1982
Quest	Postemergent	Industrial	1982
EL-107	Preemergent	Wheat	NA
Fusilade	Postemergent	Soybeans	1983
S-734	Preplant incorporated	Soybeans	1985

Source: (5).

Table 11.—New synthetic pyrethroids already marketed or still in research and development stage

Common Name	Range rate
	lbs. active ingredient/acre
Fenvalerate	.1—.2
Permethrin	.1—.2
Cypermethrin	.025—.1
Flucythrinate	.025—.1
Fenpropathrin	.05—.1
Fluvalinate	.05—.1
Cyfluthrin	.05—.1
Tralomethrin	.013—.02
Decamethrin	.01

Source: (11).

Fungicides

Manufacturers have recently developed some new systemic fungicides. Absorbed by the plant crop either through the roots or leaves, the fungicides remain effective throughout the growth of the crop. Among the new generation of systemic fungicides are: diclobytrazol, which controls powdery mildew and rusts of small grain cereals; benalaxyl, which controls downey mildew on grapevines and hops; and fenfuran, which controls smuts and bunts on cereals.

Pesticide Application

Improved application techniques and equipment hold considerable promise for better pest control, higher yields, and lower costs. A Nebraska survey reported that one-third of the ground pesticide applicators in certain areas used faulty application equipment or techniques. Montana State University researchers reported that poor application procedures have caused about $1 billion in annual losses to U.S. farmers in recent years because of lower crop yields, and pesticide wastage.

Extension Services, pesticide companies, and commercial applicators conduct clinics to monitor sprayer pressure, flow rate, velocity, and nozzle wear and adjustment. Proper equipment adjustment, along with some new pesticide formulations and controlled droplet appli-

cation, can reduce drift, which in turn improves crop coverage and minimizes environmental problems. Accurate calibration of application equipment is especially critical for materials used at very low rates such as synthetic pyrethroids. Postemergent herbicides also require accurate application to avoid damage to the growing crop. For ground applications, special nozzles with adjustable flow rates are also available. When attached to the end of the spray boom, the nozzles prevent skips in the application pattern, so that the applicator need not make an extra pass.

Equipment is also being developed that electrically charges pesticide droplets. When used, these applicators can more effectively target the pesticide, which is attracted to the crop foliage.

Long Term Outlook

Growth in world pesticide use is likely to decline from its historic annual rate of 5.8 percent between 1966 and 1980 to an average annual rate of 2.3 percent from now until 1995. The insecticide growth rate is expected to decline from 3 percent to about 2 percent. An anticipated decline in fungicide use is largely due to the continued replacement of organic by inorganic materials which are used at lower rates. In the developed countries, growth is expected to drop to only 1 or 2 percent per year because of improved formulations and government restrictions on the use of certain pesticides.

It is estimated that 75 percent of world agrichemical sales take place in North America, Europe, and Japan. However, market growth in these areas has slowed. Western Europe appears to offer only limited market growth potential for postemergent herbicides and synthetic pyrethroid insecticides. Minimum tillage and pest management systems, which employ some of the newer, specialized products, have not been as widely practiced abroad as in the United States, except for in England, where minimum tillage originated.

Growth in world markets is likely to shift toward developing and centrally planned countries as they focus greater attention on pesticides to improve crop yields. In high growth areas, demand may rise by an average of 8 to 10 percent per year. Promising markets include Eastern Europe, despite its shortage of hard currency, and the USSR. Pesticide exporters may engage in barter agreements to further penetrate this market. Among developing countries, those offering the most potential for market growth are Brazil, Mexico, and India. The developing countries are likely to continue using 5 or 6 percent more pesticides per year as many of the countries strive to obtain a better balance between fertilizer and pesticide use. According to some analysts, inadequate use of pesticides and poor management practices have caused crop losses of 30 to 60 percent, versus 20 to 30 percent for developed countries.

ENERGY

Lower gasoline and diesel fuel prices highlighted the farm energy situation in 1982. Lowest prices occurred in the second quarter with bulk gasoline averaging $1.08 per gallon, 18 percent below the record $1.31 during second-quarter 1981. Diesel fuel prices dropped 8 percent in the same period. Lower prices, together with continuing substitution of diesel fuel for gasoline, resulted in savings to farmers for petroleum fuel estimated at $420 million—5 percent below 1981. This was offset by an increase of about $380 million in electricity expenses and a roughly $20-million rise in LP gas expenses. Total energy expenses declined about $20 million—less than a 1 percent drop from 1981.[1]

The average farm electricity price rose to 6.3 cents per kilowatt hour (kwh) in 1982, up 19 percent from 1981 (table 12). LP gas prices increased only one cent to $.71 per gallon, well below the 6-percent rise in the GNP price deflator. Prices paid by farmers for natural gas climbed an estimated 20 percent to $3.90 per thousand cubic feet (mcf). Overall, farm energy prices were up less than 1 percent in 1982, far less than the 1982 inflation rate. The amount of energy used in agriculture remained essentially flat compared with 1981.

Energy Outlook—Prices

Petroleum supplies should be ample and prices down considerably in 1983, while natural gas, LP gas, and electricity prices rise. Energy price and supply projections are based on the following five assumptions: (1) there will be a modest economic recovery in 1983, (2) the Organization of Petroleum Exporting Countries (OPEC) reference price will not be severely weakened, (3) the PIK program is diverting substantial acreage out of production, (4) any major revision of the Natural Gas Policy Act of 1978 (NGPA) will not take effect this year, and (5) fuel supplies will not be interrupted by a major political disruption in the Middle East.

Diesel fuel prices are expected to average about $.98 to $1.02 per gallon during 1983, down from $1.11 in 1982 (table 12). Farm bulk gasoline will average about $1.18 per gallon in 1983, 3 to 5 percent below the 1982 price.[2] To be consistent with published farm prices, bulk gasoline prices include the 9-cent per gallon Federal excise tax which farmers are not required to pay. Small farmers can claim credit for the tax when filing their income tax. Large farm diesel and gasoline users are exempt from the Federal excise tax prior to payment. Agricultural diesel fuel prices do not include excise taxes.

If OPEC and the domestic and world economies are relatively weak in 1983, average gasoline prices could fall as low as $1.00 per gallon with diesel fuel averaging $.95 per gallon. On the other hand, with a very robust economic recovery and a tighter world oil market, farm bulk gasoline prices could average $1.25 per gallon with diesel fuel costing as much as $1.14.

The major factor determining domestic petroleum fuel prices is the world crude oil price. Transportation costs are quite small compared with crude oil costs and provide no significant barrier to oil movements. OPEC has been quite successful in restricting production to maintain crude prices, despite its declining share of world oil production. Since 1973, OPEC countries generally have been willing to restrict output to keep prices at agreed-

[1]Natural gas and fuel oil expenditures are excluded from energy expenses. Direct natural gas expenditures by farmers are a relatively small cost share and used by a very small percentage of farmers, making year to year changes statistically unreliable. Fuel oil, based on 1978 Census estimates, is a very small percentage of total energy used and is aggregated with kerosene in the Farm Production Expenditure Surveys [17] thus making it impossible to obtain reasonable annual estimates of farm annual fuel oil expenditure or use.

[2] These projections are based on the assumptions cited previously. Because of uncertainties concerning OPEC and the economy other price possibilities are discussed in the final section of this chapter.

Table 12.—Agricultural energy prices, 1981, 1982, and projected 1983

Type of energy	Average price			Percent change	
	1981	1982	Projected 1983[1]	1981-1982	Projected 1982-1983
		Dollars		*Percent*	
Gasoline[2] (Gallon)	1.29	1.23	1.17 to 1.19	−5	−3 to −5
Diesel fuel[3] (Gallon)	1.16	1.11	.98 to 1.02	−4	−8 to −12
LP gas (Gallon)	.70	.71	.75 to .77	1	6 to 8
Electricity (Kilowatt hour)	.053	.063	.067 to .069	19	7 to 9
Natural gas (1,000 cubic ft)	[4]3.24	[5]3.90	4.13 to 4.21	20	6 to 8

[1]Assumes base crude oil price of $28.50 per barrel average for 1983. [2]Bulk delivery sales, includes State and Federal excise taxes. [3]Excludes federal and state excise taxes. [4]American Gas Association estimate. [5]USDA-ERS estimate.

Sources: (1, 2, 4, 9).

upon levels. From 1973 to 1981, there was little price shaving by OPEC members. However, in the last 2 years, several factors led to fairly widespread price cutting by OPEC (and non-OPEC) oil exporters.

As in any controlled market, problems arise when the level of demand at the set price is lower than the production quotas agreed upon. Given high interest rates, high crude oil prices, and indications that supplies were abundant, refiners reduced inventories. This action and reduced gasoline consumption, induced by high prices and the worldwide recession, caused total crude petroleum demand to fall sharply. The result was a decline in world crude oil prices.

From the first quarter of 1981 to the third quarter of 1982, total U.S. oil imports dropped from 4.8 million barrels per day (MMB/D) to 4.0 MMB/D. Non-OPEC exporters increased their share of the U.S. imported oil market from 55 percent in January 1981 to 80 percent in September 1982. As a result, total OPEC exports to the United States dropped from 2.2 MMB/D to .98 MMB/D. U.S. imports of Saudi Arabian crude fell from 1.1 MMB/D during first-quarter 1981 to .5 MMB/D during third-quarter 1982.

Gasoline and diesel fuel prices, after some increases in the second quarter, will likely stabilize for the final two quarters of 1983. The relative weakness of OPEC's pricing structure has been rectified since Saudi Arabia lowered its posted crude price to $29 per barrel. A modest recovery in the U.S. economy has stimulated demand for petroleum products, and a relative tightening of the domestic petroleum product market took place in the second quarter of 1983. World crude prices appear to have stabilized in terms of the U.S. dollar.

LP gas prices during 1983 are expected to average 6 to 8 percent above 1982. While over 70 percent of marketed LP gas is produced from natural gas, LP gas demand is generally related to fuel oil demand. The low volume of natural gas production, because of the rapid rise in natural gas prices in the weak economy, has limited LP gas supplies. Two special factors tightened the U.S. market in early 1983: (1) LP gas was exported to meet demand that was supposed to have been filled by Saudi Arabian exports to Japan; (2) Phillips Petroleum Company, as a major LP distributor in the upper Midwest, has had its supply curtailed by regulatory rulings of the Oklahoma Natural Gas Commission. The Saudi Arabian LP gas plant came on stream late. To fulfill the LP gas supply contracts negotiated with the Japanese, the Saudis had to purchase LP on the U.S. market. The volume of Saudi production has been far short of capacity because of its relatively small crude oil production (of which LP gas is a byproduct). Until other suppliers fill the gap in Phillips' production loss, there may be a relative increase in the midwestern LP gas price.

As the general economy improves, the petrochemical industry will increase its demand for LP, further tightening the market. Fortunately, the recovery will also stimulate natural gas production, making LP increasingly available. As a result, there should be no overall shortage of LP gas in 1983. The amount of LP exports to Japan should also tail off by the end of 1983 as Saudi crude production increases modestly, thereby increasing Saudi LP gas production. The pickup in petrochemical demand and continued tight supplies will spell a modest 6 to 8 percent LP gas price rise in 1983.

Natural gas and electricity prices are also expected to rise significantly faster than the inflation rate. The average farm electricity price may advance about 8 percent to $.068 per kwh, while the U.S. average natural gas price, based on cost pass-through provisions of the NGPA, is likely to rise 6 to 8 percent to about $4.13 to $4.21 per mcf.

Petroleum Supplies

Domestic petroleum products supplied in 1982 totaled 15.2 MMB/D, 18 percent below 1978 (table 13). Domestic crude oil and natural gas production has remained almost constant at about 10 MMB/D for the past 10 years. Declining production in the continental United States was offset by expanding production from the Alaskan oil fields. Reduced imports accounted for the entire drop in U.S. supplies. Net imports in 1982 were only half the peak 1977 level. In addition, private stocks declined by 78 million barrels. Private crude stocks dropped 9 million barrels, while product stocks dropped 69 million.

For 1983 total petroleum product supplies are expected to be down slightly to 15.1 MMB/D. Because of lower import prices and stronger domestic product demand, net imports may rise about .2 MMB/D from 4.2 MMB/D in 1982 to 4.4 MMB/D in 1983. Domestic production and private petroleum stocks will remain virtually

Table 13.—United States petroleum supplies, 1978, 1981, 1982, and projected 1983

Item	1978	1981	1982	Forecast 1983	Forecast 1984[1]
			Million barrels per day		
Products supplied:					
Domestic crude oil and natural gas liquids	10.0	10.2	10.3	10.2	10.2
Net imports	8.0	5.4	4.2	4.4	5.2
Total products supplied[2]	18.8	16.1	15.2	15.1	15.5
Stock change	.5	−.5	−.2	.0	−.1
			Million barrels		
Ending stocks:					
Total crude	376	594	648	658	694
SPR crude[3]	67	(230)	(293)	(353)	(394)
Private crude stocks	309	364	355	305	300
Gasoline	238	253	237	230	228
Distillate	216	192	181	170	123
Residual	90	78	68	59	56
LP gas	132	135	103	—	—
Other	225	231	191	—	—
Total non-SPR stocks	1,210	1,253	1,135	1,085	1,062

[1]Ending stocks as of June 30, instead of December 31. [2]Total products supplied not equal to sum of domestic crude and imports and stock drawdown because of processing gain. [3]SPR, strategic petroleum reserve stocks, not added because included in total stocks.

— = Not available.

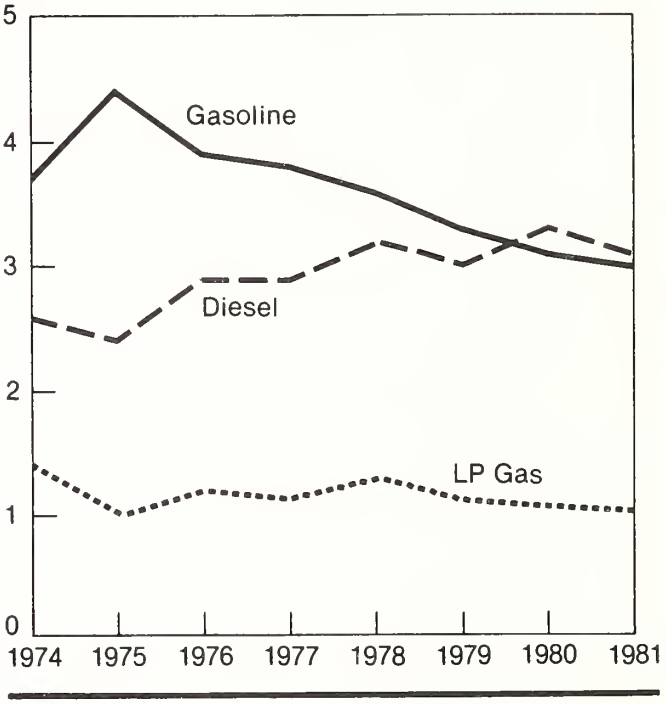
Sources: (6, 9).

unchanged. For the first half of 1984, the Department of Energy projects total petroleum supplies at a rate of 15.5 MMB/D. Larger demand would be met by increasing imports to 5.2 MMB/D, up 24 percent from 1982 and 18 percent above expected imports in 1983.

Farm Energy Use and Expenditures

Since 1975, farmers have made a substantial shift from gasoline to diesel fuel. This is largely the result of replacing older gasoline-powered tractors with diesel-powered units. In 1975 farmers used about 4.4 billion gallons of gasoline and about 2.4 billion gallons of diesel fuel. In 1980 for the first time, farmers used more diesel fuel (3.3 billion gallons) than gasoline (3.1 billion gallons).

Farm Fuel Use



Total farm gasoline use in 1983 is expected to drop to between 2.4 and 2.5 billion gallons (table 14). Diesel fuel use is likely to decline to between 2.7 and 2.8 billion gallons, from an estimated 3.2 billion in 1982 and 3.1 billion in 1981. The major cause for reduced fuel use is smaller acreage.

Continued high energy prices have encouraged fuel conservation, also contributing to the decline in energy use, especially in the late 1970's. Farm output per unit of direct energy use increased from 1978 to 1980 at an annual rate of 6.6 percent, compared with only 1.7 percent a year from 1974 to 1978 (table 15). Output per unit of direct energy increased 20 percent from 1974 to 1980.

Energy requirements per unit of output are likely to continue to decline in 1983. This decline and the expected drop in farm output are the reasons energy use will be down this year. The drop in planned farm output could interfere with rising energy efficiency, as there are certain fixed energy requirements to maintain a field and

Table 14.—Agricultural energy use, 1981, 1982, and projected 1983

Type of energy	Unit	1981[1]	1982[2]	Projected[3] 1983	Percent change 1981-1982	Percent change Projected 1982-1983
			Billion units		*Percent*	
Gasoline	Gallons	3.0	2.8	2.4 to 2.5	−7	−11 to −14
Diesel fuel	Gallons	3.1	3.2	2.7 to 2.8	3	−12 to −16
LP gas	Gallons	1.0	1.0	.75 to .85	0	−15 to −25
Electricity	Kilowatt hours	40.0	40.0	37.5	0	−5

[1]Based on prices and estimates in (14, 17). [2]Estimated by USDA-ERS [3]USDA-ERS projection

Table 15.—Energy and farm productivity shifts, 1974-1980

Year	Output per unit of Direct energy	Output per unit of Indirect energy	Output per unit of Labor	Direct energy[1]	Indirect energy	Farm labor	Output
				Index (1974=100)			
1974	100	100	100	100	100	100	100
1978	107	107	134	107	107	86	115
1980	120	96	139	96	120	83	115
				Annual growth rate (percent)			
1974-78	1.7	1.7	7.3	1.7	1.7	−3.8	3.5
1978-80	6.6	−5.4	1.8	−5.4	−5.7	−1.8	0.0
1974-80	3.3	−0.7	5.5	−0.6	3.0	−3.1	2.3

[1]Direct energy includes the gasoline, diesel fuel, fuel oil, LP gas, electricity, coal, and natural gas used in activities on the farm. Indirect energy is that used in producing other agricultural inputs such as pesticides and fertilizers.

Source: (13).

Energy and Farm Productivity

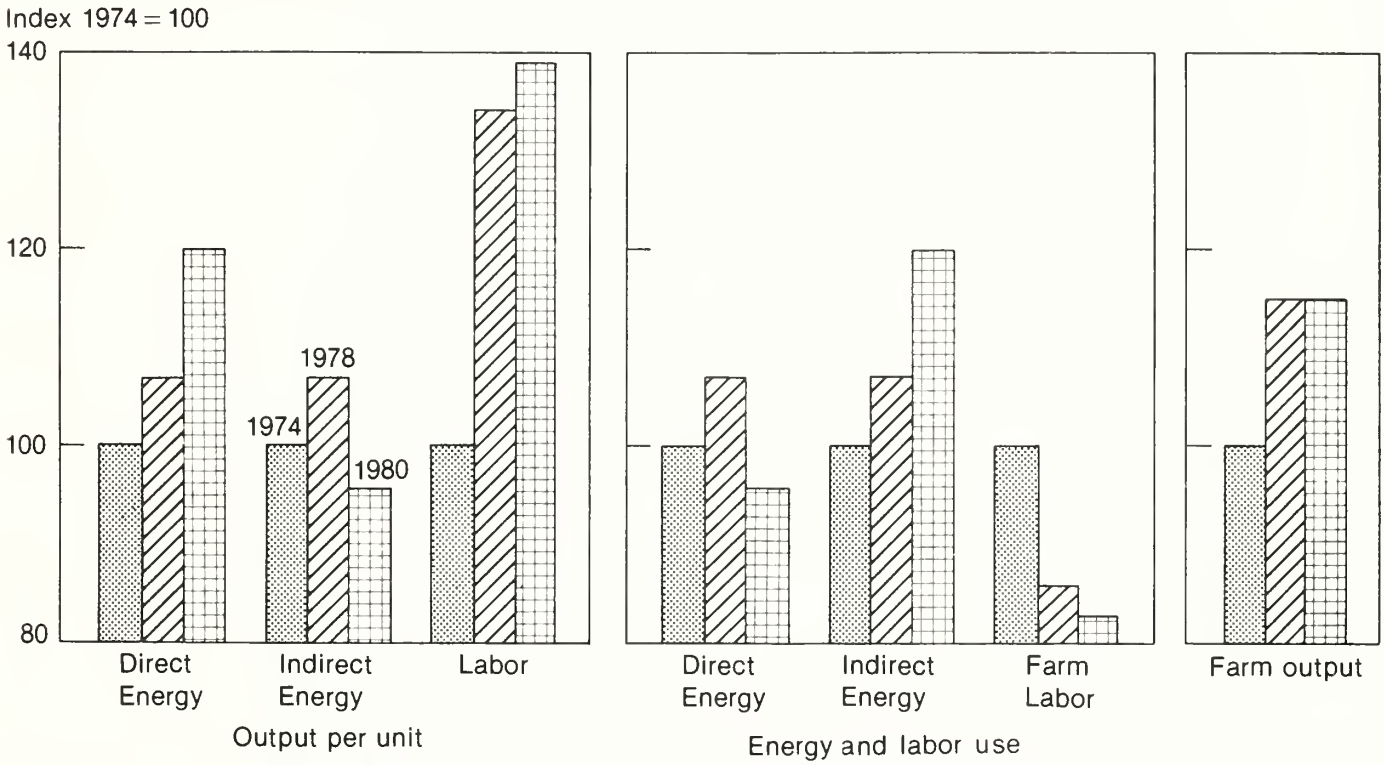


Table 16.—Agricultural energy expenses for 1981, 1982, and projected 1983

Type of energy	1981[1]	1982[2]	Projected[3] 1983	Percent change 1981-1982	Percent change Projected 1982-1983
	Billion dollars			*Percent*	
Gasoline	3.93	3.44	2.81 to 2.98	−9	−14 to −18
Diesel	3.48	3.55	2.65 to 2.86	−4	−19 to −25
LP gas	.71	.71	.56 to .65	3	−8 to −21
Electricity	2.14	2.52	2.51 to 2.59	17	0 to −3
Total	10.24	10.22	8.53 to 9.05	−1	−11 to −17

[1]Gasoline and diesel use estimates presented in table 14 above, were taken from (17) and multiplied by the respective prices from (14), presented in table 13 above, to generate the 1981 gasoline and diesel expense estimates. LP gas and electricity expense estimates are based on expenditure estimates reported in (17). [2]ERS estimate, USDA. [3]ERS projection, USDA.

operate a farm, but it should not be enough to cause an overall decrease in energy efficiency.

Because of reduced consumption and lower prices, farmers' energy expenditures should fall from an estimated $10.22 billion in 1982 to between $8.53 and $9.05 billion in 1983 (table 16).

Embodied Energy: Fertilizer As A Natural Gas Product

The drop in direct agricultural energy use from 1974 to 1980 was accompanied by an increase in the use of indirect energy in the form of fertilizer and pesticides. As direct energy use dropped 4 percent, indirect energy use rose 20 percent (table 15). This essentially reflects the overall substitution of relatively cheap fertilizer and pesticides for more expensive petroleum fuels, especially during 1978-80.

The Natural Gas Policy Act of 1978 (NGPA), which authorized natural gas deregulation, has had only a relatively small impact on fertilizer prices. Major reasons for the small impact were weak demand for fertilizer last year and growing imports. Natural gas prices have risen sharply for many ammonia producers causing large increases in operating costs. This cost/ price squeeze has resulted in reduced profits for nitrogen producers or losses for many firms, with about one-fourth of the ammonia-producing capacity shut down in the early part of 1983. This squeeze has resulted despite the partial protection of the fertilizer industry from the full price impacts of NGPA deregulation on other industrial gas users. Many of the fertilizer plants still operating have long term low price natural gas supply contracts. While farm prices have been minimally affected so far, natural gas deregulation and expiration of some long term gas supply contracts may have some fairly large price impacts on the food system in the future.

Higher fertilizer prices could limit the substitution of fertilizer for other inputs in farm production. This in turn could inhibit farm productivity growth. However, even with a doubling of the fertilizer producer's natural gas costs, farm expenditures for nitrogen fertilizer would likely increase no more than 15 to 20 percent or $.5 to $1.0 billion. The impact of this increase would be concentrated in certain types of operations. Corn, wheat, cotton, rice, and sorghum producers would absorb about 60 percent of the price impact, with corn alone accounting for almost 50 percent.

Industry analysts do not anticipate substantial increases in fertilizer prices in the next several years. An increased demand for nitrogen following this year's PIK-induced reduction, will be largely satisfied by imports of anhydrous ammonia. Many U.S. fertilizer producers who dropped out of production due to higher gas prices and lower demand will probably not resume production.

Partial deregulation of natural gas has been authorized under the NGPA. Numerous studies indicate that even after the phased deregulation is completed in 1985, 40 to 60 percent of the gas will still be subject to regulation.[3] Under NGPA, after January 1, 1985, there will be a great incentive for natural gas distributors who have a large percentage of regulated gas, to pay high prices for deregulated gas since their average cost will still be relatively low. Distributors with a small percentage of regulated gas committed to them will have to pay the higher going price in the unregulated market, giving them a relatively high average gas price. Over time, old gas will account for a smaller proportion of total natural gas supplies, causing this effect to diminish.

The Administration is proposing, and Congress is considering legislation, to amend the NGPA. This would result in an almost complete deregulation of natural gas. Included in this proposal are provisions which may result in substantial revisions of existing contracts. There have been several other legislative proposals for correcting some of the NGPA pricing and supply problems. The sectoral impacts of these alternatives is quite varied. (For a detailed analysis of the NGPA and natural gas pricing see the February 1983 issue of The Natural Gas Monthly (8).)

Natural gas distributors have charged different prices to different types of users in the past and are likely to do so in the future. Industrial users would likely pay natural gas prices comparable to the residual fuel oil price, on a BTU basis, while residential and farm users would pay a price near distillate fuel oil price.

Adding to the regulatory uncertainty about natural gas prices is the instability of crude oil prices. Regardless of which of the fuel oils is considered the alternative fuel, natural gas prices will go up more if crude oil prices rise and less if crude oil prices drop.

Currently (under NGPA) it appears that farmers will pay about 7 percent more for natural gas in 1983 than in 1982 (assuming a 4-percent inflation rate). Higher pipeline gas prices called for by contracts with well owners will bring cost pressure on final suppliers to ask regulators for rate increases. Five pipelines have refused to pay high prices for "take or pay" gas (contracts usually require pipelines to either accept a minimum amount of high-priced gas or pay for some fixed percentage of it). These pipelines invoked provisions of their contracts which allowed them to back out if they relinquished the right to obtain future gas supplies. Some of these pipelines were forced to do this because large excess supplies of natural gas in their market areas made distributors unwilling to pay larger price increases. The mild winter, the low price of residual and distillate fuel oil, and the lack of strong industrial activity had weakened end use demand for natural gas causing a glut on the market. A nominal national farm natural gas price increase of 6 to 8 percent is expected for 1983 as the higher wholesale price somewhat outweighs demand pressure.

In 1982, farmers spent $8.6 billion on chemical fertilizers. About half was spent on ammonia or nitrogen products derived from ammonia, and three-fourths of the cost of producing ammonia was for natural gas. Roughly $1.5 billion of last year's fertilizer expenditures represents natural gas feedstock costs. If all producers paid the same price for natural gas, doubling natural gas prices could add about $1.5 billion to fertilizer expenditures. However, because of the wide variation in prices paid for natural gas by ammonia producers, and excess capacity in the industry, the added cost to farmers would be considerably less than a full cost pass-through. Fertilizer producers will likely absorb a major share of further price increases in lower profitability.

The Impact of Lower Energy Prices on Farm Income

Lower petroleum prices are likely to raise GNP an additional $40 to $50 billion in 1983 while taking about

[3]This gas, known as old gas, is from wells producing prior to February 19, 1977.

Table 17—Impacts of lower fuel prices on farm income for 1983

Item	Unit	Projected petroleum price impact[1]
Extra GNP growth	Billion $	45.0
Lower inflation rate	Percent	−0.7
Farm income (cash receipts)	Billion $	0.75
Expenses	Billion $	−0.28
Net income increase	Billion $	1.03

[1]GNP multiplier from (11) and GNP impact on cash receipts derived from (12).

.7 percent off the growth in the GNP price deflator. As a result, farm cash receipts should rise $.75 billion above what they would have been with constant real energy prices. Lower direct and indirect energy prices will cause farm expenses to fall about $.28 billion (table 17). Therefore, net farm income should increase about $1 billion. Farm income should rise even further with anticipated increases in farm exports associated with improved world economic conditions. These improvements may not be realized until 1984, however.

Prospects for 1984 Prices

Energy price forecasts for 1984 based on (9) assume a continued but modest economic recovery as well as assumptions similar to those for 1983, including an effective crude oil price of about $28 per barrel. As a result, bulk gasoline prices are likely to average about $1.22 per gallon, 3 percent above 1983. Diesel prices could rise 10 to 12 percent. LP gas could advance by about 8 or 9 percent, reflecting higher natural gas prices and increased demand from the petrochemical industry. Electricity prices can be expected to rise about 6 percent over 1983.

A natural gas price increase of about 10 percent is expected in 1984. This assumes a 4 to 5 percent GNP rate of growth and no changes. This growth rate should tighten the natural gas markets, increasing demand to be roughly equal to the amount available at prevailing prices. A weaker than anticipated economic recovery could result in an increase of only 4 to 5 percent in the average 1984 natural gas price compared to 1983. A severe winter and rapid GNP growth could cause 1984 natural gas prices to rise 15 percent above 1983. Again, as mentioned above, impacts on fertilizer prices could be expected to affect primarily cash grain and cotton farmers.

Alternative Petroleum Pricing Possibilities

In March 1983, the official OPEC price dropped from $34 to $29 per barrel. In reality the cut is less than it appears, as the effective world crude price at the end of 1982 was about $32.50 per barrel. Three factors explain why the official Saudi price of $34 per barrel exceeded the actual price, which is estimated at $30 a barrel during first-quarter 1983: (1) In December 1982, the Saudi price established the floor price for OPEC countries, while in January 1982 it had been the ceiling price. (2) There were increased spot market sales in 1982 (of about 10 percent of the total crude at below $30 per barrel). (3) A number of OPEC and non-OPEC exporters gave explicit and implicit discounts from their official quoted prices.

Crude oil most likely will sell for about $28 per barrel in the second, third, and fourth quarters of 1983. The underlying assumption is that the 1983 OPEC pact will be generally successful in sustaining prices with the allocated oil output. Although some price shaving, spot market discounting, and non-OPEC price undercutting is expected to continue, these would not be enough to undermine the OPEC price and output accord. This projection also assumes that U.S. GNP will grow at a 4 to 5-percent annual rate for the last 3 quarters of 1983. Notable in the March 14 accord is the official recognition of Saudi Arabia as the swing producer. The Saudi acceptance of this role reflects its belief that the oil market will tighten in the second half of the year.

A price above $28 is possible, but appears quite unlikely and would reflect an immediate tightening of the world oil market. This might imply a spot market price average of almost $30 per barrel. A robust world recovery with an economic growth rate of about 4 percent, considerably above the consensus forecast of 2 percent, could bring this about. A limited escalation of the Iran-Iraq conflict could also tighten markets. An escalation that includes other Gulf powers and interrupts shipping in the Gulf of Iran would cause even larger price increases.

A lower price, while unlikely, could result if: (1) the OPEC price agreement is broken, or (2) if a slower-than-expected economic recovery is coupled with a large non-OPEC production increase. Oil prices could fall to $20 per bbl by fourth-quarter 1983. This would likely induce oil import restrictions (either tariffs or quotas) by Western governments to prevent massive financial collapse.

FARM MACHINERY

Outlook for 1983

Low farm prices, high interest rates, and high farm sector debt have depressed the early outlook for 1983 farm machinery sales. In addition, acreage reduction programs have substantially decreased crop area, and may slightly reduce the need for new farm machinery, especially machinery and equipment used in corn and cotton production. In spite of this, the sales decline of the past years is expected to moderate because of a turn around toward the end of the year. While retail sales in the first 4 months of 1983 were again off for tractors and some other items, sales of combines and some haying equipment rose substantially. Many dealers reported substantial machinery sales gains in April and May as farmers used money they might otherwise have spent on other variable inputs to buy machinery. Also, some companies were offering credit advances on PIK payments to sell equipment. Farm machinery sales, which totaled about $10 billion in 1982, are expected to be least affected of all farm inputs by 1983 acreage reduction programs. Because of the programs, the need to replace farm machinery is expected to drop slightly more than 2 percent.

While prospects for only a modest improvement in farm income will continue to hold farmers' capital expenditures in check, Government support programs should strengthen machinery sales. Direct Government payments to crop farmers increased through the spring of 1983, reflecting advances on deficiency and acreage diversion payments to those farmers who signed up for

the 1983 programs. The advance payments helped ease the cash-flow squeeze faced by many crop farmers. If production is significantly reduced as a result of the acreage reduction programs, grain prices could improve. Higher crop prices, along with the possibility of further declines in interest rates, should stimulate purchases of farm equipment. In addition, the PIK program could help to support a recovery in farm equipment sales in the second half of 1983. The recovery could be the beginning of a new look for the farm equipment industry.

Total farm equipment unit sales may remain flat in 1983 but modest price advances (below those of recent years) may cause receipts to equal or exceed last year. To offset a tractor sales drop of more than 16 percent in the first 4 months of 1983, unit sales for the remainder of the year would need to rise an average of more than 5 percent.

The overall demand for maintenance, parts, and repairs is expected to decrease with the reduction in planted acreage. Repairs and maintenance expenses may drop as much as 12 to 15 percent. Per acre costs for maintenance and repair, however, tend to increase with reduced acreage because there are certain fixed costs regardless of acres. Savings from repairs and maintenance may be quite high for some crops, because with field work demanding less of their time, growers will be able to do more of these activities.

The PIK program should be a positive force in the longer run in fostering a recovery in the farm machinery market. The PIK program will reduce farm production expenditures, enabling many farmers to improve their cash flow situation and reduce their debt burden that has grown in recent years. While contributing to the financial health of the farm sector, these improvements would increase funds available for machinery purchases.

Poor Sales Continue to Reflect Weak Farm Income

Poor sales of the last 3 years reflect low farm incomes, as farmers continued to put off buying new equipment (table 18). In 1982, retail sales of farm tractors with 40 or more horsepower were about 26 percent below 1981 and down 45 percent from the strong sales period of 1978-79. Self-propelled combine sales were 33 percent below 1981 and about 50 percent below record sales 3 years earlier. Retail sales of forage harvesters were off by 40 percent from 1981 and almost 50 percent below the number of units sold in 1979.

The downturn in farm equipment sales accelerated as 1982 wore on: year-to-year declines in tractor sales (40 or more horsepower) widened from 9 percent in first-quarter 1982 to 29 percent in the second quarter, 30 percent in the third, and 32 percent in the last quarter. The decline continued into 1983 with first-quarter sales off 18 percent from a year earlier. Combine sales also deteriorated during most of 1982. During March-November, combine sales remained about 40 percent below the year earlier. However, in December, combine sales registered an increase—the only major type of equipment to do so. Sales during first-quarter 1983 rose about one-third over first-quarter 1982. Forage harvester sales for the first quarter of 1983 were off 22 percent from the same period a year earlier.

Unit Sales of Farm Machines and Farm Income

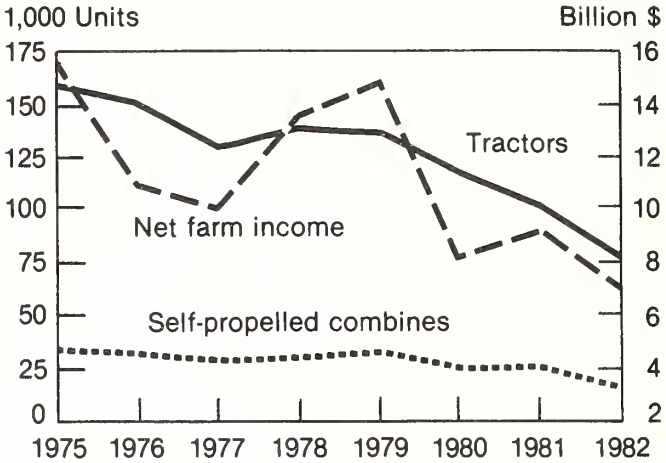


Table 18.—Sales of selected farm machinery and net farm income, 1975-1982

Year	Tractors		Self propelled combines		Forage harvesters		Net Farm Income Current dollars		Net Farm Income 1967 dollar	
	1,000 units	*Percent change*	*1,000 units*	*Percent change*	*1,000 units*	*Percent change*	*$ Billion*	*Percent change*	*$ Billion*	*Percent*
1975	160.9	NA	33.0	NA	13.1	NA	25.2	NA	15.7	NA
1976	152.7	−5.1	32.5	−1.5	13.3	1.6	18.7	−25.8	10.9	−30.5
1977	130.7	−14.4	28.8	−11.4	10.5	−11.1	18.4	−1.6	10.2	−6.4
1978	140.0	7.1	31.5	9.4	11.6	10.5	26.7	45.1	13.6	33.3
1979	139.0	−0.7	32.2	2.2	12.5	7.8	32.3	21.0	14.9	9.5
1980	119.3	−14.1	25.7	−20.2	9.5	−24.0	20.1	−37.8	8.2	−45.0
1981	103.8	−13.0	26.8	4.3	7.6	−20.0	25.1	24.9	9.2	12.2
1982	77.1	−25.7	16.2	−39.6	5.1	−32.9	20.4	−19.7	7.1	−32.8
1983[1]	NA	−16.5	NA	31.0	NA	−21.7	NA	NA	NA	NA
						Percent change				
1979-82	NA	−44.5	NA	−49.7	NA	−59.2	NA	−36.2	NA	−52.3

[1]First quarter.

— = Not available.

Sources: (1, 3).

Sales of other categories of farm machinery and equipment also declined last year. Unit retail sales of balers (producing bales weighing less than 200 pounds) were off about 35 percent from 1981, continuing a general decline that started in 1973 with the introduction of round bales. Mower conditioner sales were down 25 percent from 1981. Sales of most machinery items continued to decline into the first quarter of 1983; however, mower conditioner and baler sales were up along with combines.

Since the early 1970's, declining sales of windrowers, manure spreaders, disc harrows, plows, and other equipment items have contributed to an overall drop in farm equipment sales.

Inventories Burdensome

Lower sales have created burdensome dealer and manufacturer inventories. While the December 1982 inventory of unsold farm tractors was down from a year earlier, it still equaled the number of tractors sold over the previous 12 months. The inventory of 2-wheel drive tractors equaled about 125 percent of the units sold in the previous year, compared with a desirable stock level of less than 50 percent. Unsold 4-wheel drive tractors amounted to nearly 90 percent of the previous year's sales.

Farm Machinery Industry Adjusts To Reduced Sales

Shutdowns, layoffs, tightened inventories, and general retrenchment have been widespread in recent years as the farm machinery industry attempted to adjust to sagging sales. To prevent rising inventories and to minimize costs, manufacturers resorted to lengthy plant shutdowns that seriously affected employment and payrolls.

The number of workers employed by farm machinery and equipment manufacturers during fourth-quarter 1982 was down more than a third from 3 years earlier. Manufacturers have tried promotional campaigns and programs to bolster sales, including rebates, discounts, lower finance charges or waivers of a portion of the interest payment, and credit advances on PIK payments.

According to a recent Farm Equipment Manufacturers' Association survey, about 426 farm machinery dealers went out of business in 1981 and about 450 in 1982, reducing to about 10,000 the total number of U.S. farm machinery retailers. In addition, declining sales and profit margins have, no doubt, adversely affected most farm machinery dealers that remain in business.

Farm Machinery Price Increases Slow

While unit sales dropped drastically in recent years, prices continued to show substantial increases, averaging more than 10 percent in 1980 and 1981 and 8 to 9 percent in 1982, reflecting inflation and higher quality machine items (table 19). Annual price increases in the last 10 years for tractors and self-propelled equipment ranged from 6 percent in 1972 to 21 percent in 1975. Since 1975, increases have generally been between 9 and 12 percent. Prices for other farm machinery rose roughly 11 percent a year since 1972. As of March 1983, 110-129 horsepower tractor prices averaged $39,300 and 170-240 horsepower units averaged $77,800 (table 20). Continued weak demand for farm machinery should keep price increases below a year earlier. As of March 1983, farm machinery prices had risen only 2 to 3 percent from last fall.

In 1982, tractor and other machinery prices increased 8 to 9 percent over 1981 while prices of all production inputs rose only 1 percent and farm crop prices dropped an average of 10 percent (table 19). When examining trends over the last 5 or 10 years, prices have climbed more rapidly for farm machinery than for all input items or for farm crops. During 1972-82, tractor and other

Table 19.—Index of prices for tractors and self propelled equipment, other machinery, all production items, and crops, 1972-1983 - Indexes (1914=100)

Year	Prices paid for:				Prices received for:			
	Tractors and self propelled equipment		Other machinery		All production items		All crops	
	Index	*Percent change*	*Index*	*Percent change*	*Index*	*Percent change*	*Index*	*Percent change*
1972	651	—	590	—	351	—	257	—
1973	695	6.8	633	7.3	424	20.8	394	53.3
1974	816	17.4	725	14.5	481	13.4	504	27.9
1975	990	21.3	895	23.4	528	9.8	452	−10.3
1976	1102	11.3	1025	14.5	559	5.9	443	−2.0
1977	1205	9.3	1120	9.3	579	3.6	433	−2.3
1978	1315	9.1	1211	8.1	628	8.5	456	5.3
1979	1466	11.5	1332	10.0	720	14.6	501	9.9
1980	1640	11.9	1483	11.3	798	10.8	539	7.6
1981	1831	11.6	1637	10.4	855	7.1	580	7.6
1982	1982	8.2	1789	9.3	864	1.1	525	−9.5
1983[1]	2076	4.7	1884	5.3	880	1.9	523	−.4
				Percent change:				
1972-82	NA	204	NA	203	NA	146	NA	104
1975-82	NA	100	NA	100	NA	64	NA	16
1979-82	NA	35	NA	34	NA	20	NA	5

[1]March 1983.

NA = Data not available.

Source: (4).

Table 20.—Prices of tractors, combines, and forage harvesters, 1975-1983

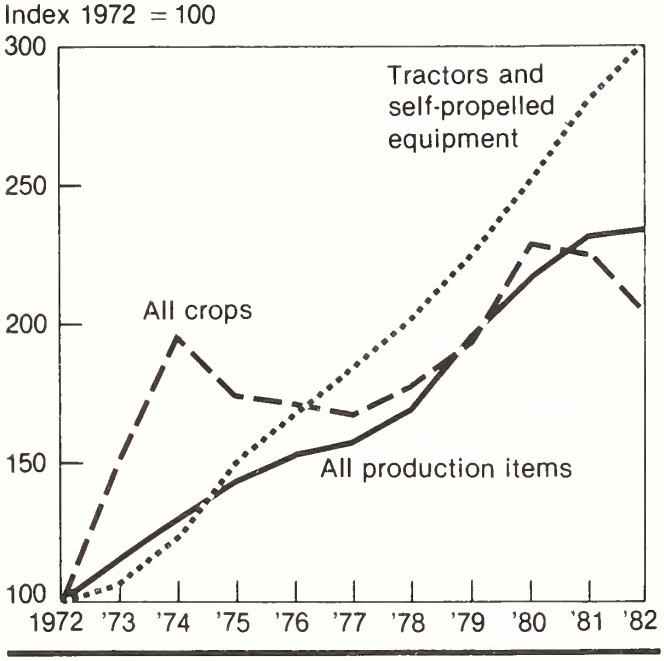
Year	Tractors (horsepower range) 50-59		110-129		170-240		Self propelled combines		Forage harvesters	
	Dollars (Sept.)	*Percent change*	*Dollars (June)*	*Percent change*	*Dollars (June)*	*Percent change*	*Dollars (Sept.)*	*Percent change*	*Dollars (June)*	*Percent change*
1975	$8,790	NA	$19,200	NA	$39,600	NA	$28,300	NA	$5,460	NA
1976	9,350	6.4	21,300	10.9	43,000	8.6	32,100	13.4	6,070	11.2
1977	10,200	9.1	23,600	10.8	45,700	6.3	36,100	12.5	6,960	14.7
1978	11,200	9.8	25,000	5.9	48,300	5.7	41,000	13.6	7,680	10.3
1979	12,300	9.8	28,300	13.2	55,100	14.1	44,900	9.5	8,620	12.2
1980	13,800	12.2	31,300	10.6	62,300	13.1	49,200	9.6	9,720	12.8
1981	15,200	10.1	35,400	13.1	71,600	14.9	57,000	15.9	10,700	10.1
1982	16,200	6.6	38,000	7.3	74,300	3.8	59,900	5.1	11,800	10.3
1983	[1]17,000	4.9	[1]39,300	3.4	[1]77,800	4.7	NA	NA	NA	NA

[1]March 1983.

NA = Not available.

Source: (4)

Prices of Farm Machinery, Agricultural Production Items, and Crops



machinery prices increased 204 percent, while prices of all production items increased 146 percent and crop prices rose only 104 percent.

Higher farm machinery prices generally reflect gains in producer (wholesale) prices. Farm machinery prices rose 100 percent from 1975 to 1982, compared with a wholesale farm machinery price increase of 85 percent, a foundry and forge products price increase of 77 percent and a tractor and implement tire price increase of 66 percent (table 21).

Exports and Imports Likely To Remain at 1982 Levels

Exports of farm machinery in 1982 fell 19 percent to about $2.4 billion, following an 11-percent increase in 1981 (table 22). Canada remained the leading market with purchases of almost $1 billion, 42 percent of U.S. farm machinery exports. Australia ranked second with $218 million and Saudi Arabia third with $147 million.

Because of reduced domestic demand, imports declined 24 percent from 1981 to about $1.2 billion in 1982. The primary import sources were: Canada, $487 million or 41 percent, Japan, $181 million or 15 percent, and West Germany, $169 million or 14 percent. Tractors and tractor parts were the major type of import. Small tractors, under 45 horsepower units, came mostly from Japan, and 45 to 85 horsepower units from Europe. Imports accounted for nearly one-fourth of all U.S. farm tractor unit sales in 1982. These were mostly smaller lower priced tractors, many of which were produced by U.S. firms with production facilities in other countries.

Long Term Outlook

Worldwide demand for agricultural products will continue to increase with the United States being the major supplier, but growth will be slower than in the past. Slower growth in U.S. exports of agricultural products translates into reduced incentives for farmers to increase the use of modern and sophisticated machines as well as other production inputs. In developing countries, increased agricultural production will encourage the substitution of modern machines for hand labor and draft animals. U.S. exports of farm machinery should continue to grow, but at a decreasing rate. Developing countries require smaller and less sophisticated machinery. These units are manufactured in limited quantities in the United States but are more likely to be produced in Japan and Western Europe.

Industry Aspects

An important factor in the continued growth in U.S. farm equipment use has been the change in crop mixes in different geographic regions, where farmers have purchased specialized equipment needed for growing certain crops. Also, much of the farm machinery sold today replaces smaller units, enabling one operator with a large specialized machine to replace several operators with smaller machines. These factors will continue to stimulate machinery sales, but their importance could diminish.

Table 21.—Indexes of prices for machinery components and wholesale prices charged by agricultural machinery producer, 1975-82 (1967=100)

Year	Foundry and forge products		Tractor and implement tires		Diesel engines other than automobiles		Producer price of agricultural machinery	
	Index	*Percent change*	*Index*	*Percent change*	*Index*	*Percent change*	*Index*	*Percent change*
1975	194.3	NA	166.9	NA	172.4	NA	168.6	NA
1976	218.6	12.5	182.8	9.5	188.2	9.2	183.0	8.5
1977	237.2	8.5	194.7	6.5	205.2	9.0	197.9	17.4
1978	252.0	6.2	203.3	4.4	226.5	10.4	214.1	8.2
1979	276.5	9.7	233.1	14.6	252.6	11.5	232.1	8.4
1980	312.1	12.8	254.0	9.0	282.0	11.2	259.9	12.0
1981	332.0	6.4	270.3	6.4	326.0	15.6	288.3	10.9
1982	344.5	10.4	277.3	2.6	354.5	8.7	312.2	8.3
				Percent change				
1975-82	NA	77.1	NA	66.1	NA	105.6	NA	85.2

NA = Not available.

Source: (7).

Table 22—Value of farm machinery and equipment exports and imports, 1972 to 1982

Year	Value	
	Exports	Imports
	Million dollars	
1972	489	315
1977	1,562	1,158
1978	1,583	1,183
1979	2,187	1,880
1980	2,631	1,773
1981	2,942	1,550
1982	2,378	1,180

Sources: (5, 6).

Table 23.—U.S. market shares for tractors and combines, 1966 and 1980

Firm	Tractors		Combines	
	1966[1]	1980[2]	1966[1]	1980[2]
	Percent			
International Harvester	23	15	25	17
John Deere	22	25	35	40
Massey-Ferguson	14	10	0	14
Ford	14	17	0	NA
J. I. Case (Tenneco)	7	7	13	0
Allis-Chalmers	6	6	22	17
White Farm Equipment	8	3	0	4
Other	6	17	5	8

[1]Production numbers (18). [2]Sales numbers (2).

NA = Not available.

Sources: (2, 5, 6).

The farm equipment industry has traditionally carried out aggressive and innovative production and marketing programs. However, there are stringent demands upon manufacturers to keep up with technological improvements and remain competitive in an era of fewer machines, less frequent purchases because of long life of the equipment, and strong brand loyalties that influence most purchase decisions.

In recent years, the financial problems of farmers have had an unsettling effect on the farm machinery industry, and the instability of some major companies has affected farmer buying decisions. The farm machinery dealers' financial strength is becoming more important because of the trend toward more capital-intensive production, high interest rates, and retail financing requirements. Also, strength of the manufacturer dealer organizaton and marketing and service back-up is becoming increasingly important.

In 1980 John Deere accounted for 25 percent of U.S. farm tractor sales, and 40 percent of combine sales—larger shares than any other firm (table 23). International Harvester ranked third in tractor sales in 1980, with 15 percent of the market, down from the leading position with 23 percent of the market in 1966. Since 1980, International Harvester's share of the market continued to slide because of the company's poor financial condition and variety of other factors, including stiff competition, particularly from John Deere, and the generally poor farm economic conditions. The farm machinery and equipment industry continued to suffer from lagging sales in the first quarter of 1983. Overall sales for the top three companies (Deere, International Harvestor, and Massey-Ferguson) declined 22 percent from a year earlier.

Deere will probably gain further dominance in the farm equipment industry with up-to-date products, an extensive dealer network, and a strong financial position.

International Harvester's chances of survival, which appeared dim several months ago, appear to have improved. The company reported a net loss of $1.6 billion during fiscal year 1982, and a loss of $165 million for first-quarter 1983, versus a first-quarter 1982 loss of $276 million. After debt restructuring, other financial adjustments, and the creation of a new management team, the company stands to make a strong sales recovery when farm economic conditions improve. Massey-Ferguson reported a net loss of $413 million in fiscal year 1982 and a $94-million loss in the first quarter of 1983. Changes in management and financial structure should improve Massey's long term position.

The remaining competitors, along with International Harvestor and Massey- Ferguson, will be hard pressed to gain a greater share of the market. These firms may be forced to merge with other companies with complementary lines and join forces to turn out equipment for each other.

Emerging Technology

A new generation of bigger and more specialized machines is already moving into the fields, enabling farm operators to increase their harvests with more efficient cultivation and less labor. Some of the new equipment has shown impressive advantages in reducing the expenses of farming. However, since many farmers have accumulated large amounts of debt in recent years, they may be reluctant to purchase new expensive machinery. At least in the short term, machinery obsolescence may be viewed by farmers as a less important consideration in farm machinery purchases.

In addition, biologists are now beginning to realize results from a new field of genetic engineering that offers great potential for food and fiber production. Although genetic engineering is so new that it is impossible to gauge its ultimate impact, increasing yields of higher quality crops may enhance a farmer's ability to buy expensive equipment and may also change machinery requirements.

Tractors: Big farm tractors of 300-plus horsepower are becoming more numerous as they replace several smaller units with a saving of manpower. These powerful machines are specially designed to pull large, heavy rigs for tilling and planting large fields.

In 1981, a 650-horsepower prototype was marketed and a prototype 747-horsepower model was built. The 650 horsepower machines have been sold mostly to large wheat growers in the Southern Plains and the Pacific Northwest. These units may also be suited for no-till corn and soybean production. Modified versions of the 350-horsepower (super horsepower) tractors are already being adopted by some Midwestern corn and soybean producers who are using heavier attachments.

The large tractors have other advantages. For example, using specially designed plows with laser beams to guide them, a machine can install about one mile of continuous roll plastic pipe per hour—many times the capacity of conventional open ditch machines.

Planters: A 24-row planter which is about 6 times as large as most planters a decade ago, is now on the market. Attached to at least a 160-horse power tractor, the new planters can be equipped with liquid or dry chemical and fertilizer attachments to simultaneously till, plant, and fertilize large fields. The planter can be used with various associated field preparation equipment, or it may be adapted to minimum tillage soil preparation methods.

A recently developed no-till drill can apply as much as 2,000 pounds of packer wheel pressure per seed-opener for removing air pockets, while simultaneously banding phosphate and nitrogen fertilizers close to the seed and applying pesticides. The drill can also apply liquid, gas, or dry fertilizers. These new grain drills have much potential for reducing fuel consumption—the result of fewer trips across the field.

Sprayers: Special application equipment is readily available to increase chemical application efficiency. For example, chemicals can be applied simultaneously with other field work, such as planting and field preparation. One method is to cut a slit in the soil and apply the chemical in a narrow band below the surface in one run through the field. Conventional methods can waste substantial amounts of chemicals when they are broadcast on soil surface and then tilled into the soil with two or three trips across the field. To minimize soil compaction from heavy equipment, many new sprayers are equipped with large, flotation tires.

New tillage equipment can replace moldboard plows, which were previously needed to place phosphate and potassium fertilizers at the proper soil depth. This feature makes the new machines attractive for no-till practices.

Aerial spraying is also being improved with the use of small helicopters that can precisely service small or sloped fields that are not suited to fixed wing aircraft. The helicopter applies chemicals more precisely because it can vary its speed and altitude more easily.

Computer controls can maximize the water use efficiency of irrigation systems. An experimental computer-controlled lateral move system is equipped with lasers to keep it perfectly aligned as it moves. Its computer program can include soil and weather information, such as solar radiation, air temperature and humidity, wind speeds, soil moisture, and evaporation. As soil and weather indicate the need for water the computer will turn on the system until the crop's water needs are satisfied.

Harvesters: New large combines with up to 12-row corn heads can harvest 2,000 bushels or more an hour, about 5 times greater capacity than a decade ago. Similar improvements have been made in harvesting equipment for soybeans and wheat. Row crop headers have reduced soybean harvesting losses, while floating heads have been developed for soybean harvesting where fields are not level enough for a float sickle.

Recently a four-row cotton harvestor was introduced to allow one operator to glean about double the acreage harvested by smaller machines. Enlarged storage baskets can hold up to 5,800 pounds of raw cotton, nearly 50 percent more than the conventional two-row picker. It can harvest over 3.5 acres or 7.5 bales per hour. With these machines harvesting costs are reduced one-sixth by reducing labor and fuel inputs.

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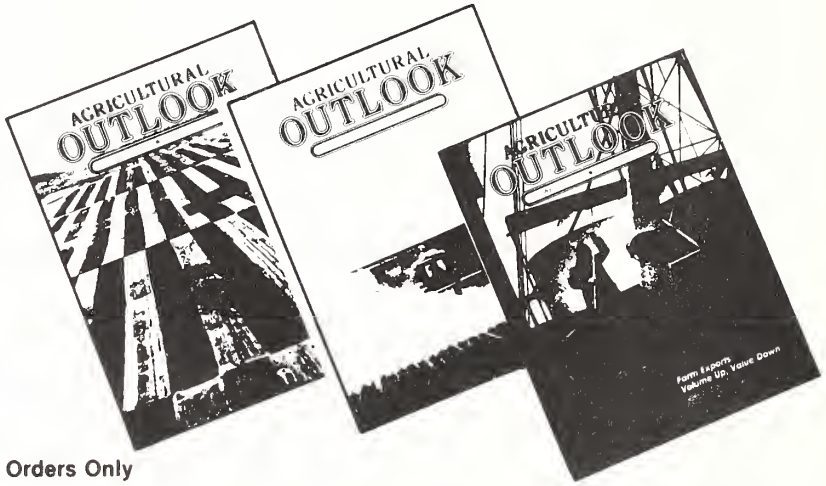

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